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Agricultura familiar: desafíos y perspectivas

Challenges of family pig production in Uruguay: Case studies linked to CALUPROCERD

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Abstract

In recent years, the Uruguayan pork market has seen an increase in imports and a decrease in local slaughter, which has made it difficult for family pig production to continue due to low income, technological lag, and low product quality. The Uruguayan Limited Agricultural Cooperative of Pig Producers (CALUPROCERD, by its Spanish acronym) emerged as an associative strategy to access a differential market and promote actions to overcome production restrictions and adopt technology on farms. This study presents the preliminary results of an ongoing project that aims to identify the strengths and limitations of the systems, detect critical points, and propose redesigns that contribute to their sustainability. A multidisciplinary team worked on extension and technical assistance based on participatory action research and co-innovation. Four producer families from southern Uruguay who commercialize through the Cooperative and are representative of breeding and full-cycle production systems were selected as case studies. The general problems that family pig production faces were identified, and through the participatory diagnosis, other issues emerged, such as productive and economic inefficiencies. The redesign plans focus on overcoming the identified limitations without compromising socioeconomic and environmental sustainability. To date, economic and productivity indicators that have reported progress include gross product, gross margin, feed margin, and net family income.

Keywords: family farming, co-innovation, participatory research, pigs, sustainability

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Desafíos de la producción familiar de cerdos en Uruguay: Estudios de caso vinculados a la Cooperativa Agraria Limitada Uruguaya de Productores de Cerdos

Resumen

En los últimos años, el mercado de carne porcina en Uruguay ha registrado un aumento en las importaciones y una disminución en la faena local, lo que ha dificultado la permanencia de la producción familiar porcina debido a los bajos ingresos, al rezago tecnológico y la baja calidad del producto. La Cooperativa Agraria Limitada Uruguaya de Productores de Cerdos (CALUPROCERD) surge como una estrategia asociativa para acceder a un mercado diferencial y promover acciones para superar restricciones productivas y de adopción de tecnologías en los predios. Este trabajo presenta los resultados preliminares de un proyecto en curso cuyo objetivo es identificar las fortalezas y las limitaciones de los sistemas, detectar puntos críticos y proponer rediseños que contribuyan a su sostenibilidad. Un equipo multidisciplinario realizó un trabajo de extensión y asistencia técnica basada en la investigación-acción participativa y la coinnovación. Se seleccionaron como estudios de caso cuatro familias productoras del sur de Uruguay que comercializan a través de la Cooperativa y son representativas de los sistemas de producción de cría y ciclo completo. Se identificaron las problemáticas generales que atraviesa la producción familiar de cerdos y con el diagnóstico participativo surgieron otras, como ineficiencias productivas y económicas. Hasta la fecha, se reportan avances en indicadores económicos y productivos: producto bruto, margen bruto, margen de alimentación e ingreso familiar neto.

Palabras clave: agricultura familiar, coinnovación, investigación participativa, suinos, sustentabilidad

Desafios da produção familiar de suínos no Uruguai: Estudos de caso vinculados ao CALUPROCERD

Resumo

Nos últimos anos, o mercado de carne suína no Uruguai registrou um aumento nas importações e uma diminuição no abate local, o que dificultou a continuidade da produção familiar de carne suína devido à baixa renda, ao atraso tecnológico e à baixa qualidade do produto. A Cooperativa Agrária Limitada de Produtores de Suínos do Uruguai (CALUPROCERD) surgiu como uma estratégia associativa para acessar um mercado diferenciado e promover ações para superar as restrições produtivas e a adoção de tecnologias nas fazendas. Este trabalho apresenta os resultados preliminares de um projeto em andamento cujo objetivo é identificar os pontos fortes e limitações dos sistemas, detectar pontos críticos e propor redesenhos que contribuam para a sua sustentabilidade. Uma equipe multidisciplinar realizou trabalhos de extensão e assistência técnica baseados em pesquisa-ação participativa e coinovação. Quatro famílias produtoras do sul do Uruguai que comercializam através da Cooperativa e são representativas dos sistemas de melhoramento e produção de ciclo completo foram selecionadas como estudos de caso. Foram identificados os problemas gerais enfrentados pela produção familiar de suínos e com o diagnóstico participativo surgiram outros, como ineficiências produtivas e econômicas. Os planos de reformulação centram-se na superação das limitações identificadas, sem comprometer a sustentabilidade socioeconômica e ambiental. Até à data, são registrados progressos nos indicadores econômicos e produtivos: produto bruto, margem bruta, margem alimentar e rendimento familiar líquido.

Palavras-chave: agricultura familiar, coinovação, pesquisa participativa, suinocultura, sustentabilidade

1. Introduction

Over the past decade, pork consumption per capita has increased in Uruguay, a trend that contrasts with the decline in national production that has been experienced since 2015[(1)]. This growth in local consumption is mainly due to the increase in pork imports, mainly from Brazil, which has particularly affected family pig producers, who must compete with imported pork at lower prices[(2)].

Pig production in Uruguay is mainly concentrated in the south, since it presents the greatest consumer demand and slaughter plants. This area also presents greater availability of by-products for animal feed, which are used

by more than 90% of farms to reduce production costs and improve economic results[3][4]. The analysis of the latest census information[5] shows that 90% of the farms mainly oriented to piglet production have low technological levels.

To improve profitability in family production systems and stop the decline of the sector, the Uruguayan Limited Agricultural Cooperative of Pig Producers (CALUPROCERD, by its Spanish acronym) became, in 2013, the commercial tool of the Association of Pig Producers protected by the Public Procurement Law[6], and began selling slaughtered pigs at a live weight of 95 kg, from family production[7][8]. Currently, most of the animals commercialized by CALUPROCERD come from members located in the southern part of the country, although the cooperative has a national reach (March 2022, conversation with Álvaro Cavallero; not referenced).

During the development of this initiative, one of the main difficulties encountered was obtaining homogeneous batches that would allow the delivery of a uniform product for sale[8], due to the coexistence of a great diversity of production systems, differing in genetics and feed[4][8].

Although the members of the Cooperative identify progress in marketing conditions, such as stability and improved prices[8], these results have not been able to promote the technological changes required to achieve the quality and quantity standards that would enable CALUPROCERD to diversify into commercial channels beyond those under the orbit of the Public Procurement Law.

To address these limitations, in 2022, the project "Participatory research for the sustainability of family pig production systems in southern Uruguay" was launched with funds from INIA-FPTA 379. The challenge was to address production systems in their three dimensions: social, environmental, and economic-productive. Between 2021 and 2024, a participatory research methodology was applied, encouraging producers to take part in problem identification, critical-point detection, and the development of practical solutions[9]. These solutions seek not only to achieve the objectives of each family but also to overcome limitations that affect CALUPROCERD's business plan.

In Uruguay, few studies address the economic performance of pig production systems. A first study published in 2002 described the main productive and economic indicators obtained from one-year monitoring of previously defined production models[10]. A more recent contribution by Oyhantçabal[11] incorporated indicators designed to evaluate multiple dimensions, aiming to analyze the sustainability of family pig production in field systems.

The objective of this article is to present some productive economic results as an advance of the ongoing project, whose scope is to identify the strengths and limitations of the systems, detect critical points, and propose redesigns that contribute to long-term sustainability. Based on the study of four pig production systems in southern Uruguay that commercialize their production through the Cooperative, the main challenges faced by family pig farmers were analyzed, as well as the evolution of key economic-productive indicators across the four farms analyzed. The social and environmental dimensions will be evaluated at the end of the redesign stage, which is currently in progress.

2. Materials and Methods

2.1 General Methodological Framework of the Research

To address the project objectives, a methodology based on the co-innovation and participatory research-action approach was implemented. The incorporation of this methodology structured the project in three major stages:

1) characterization and diagnosis; 2) development of the redesign proposal, and 3) implementation and evaluation of the proposed redesign[12].

The participatory action methodology[13] was used as a conceptual framework to involve the various actors of the project in both the diagnosis and solution design processes. Before its application, an internal training process was necessary to build a horizontal working relationship between the technical team, the producers, and the directors of the Cooperative and to foster integration across disciplines in order to address the complexity and heterogeneity of family pig production systems.

The co-innovation approach[14], designed to foster collaboration between the different actors involved –technicians, producers, and the Cooperative–, sought to create spaces to share knowledge, ideas, and experiences, to co-create viable solutions in the short and medium term[15].

The first stage of the project involved farm diagnosis, which began with visits conducted by the team from the second half of 2022 through late 2024. To address the different dimensions of sustainability, different indicators were selected, evaluated, and discussed by the technical team before their application. In turn, background information on the evaluation of natural resource management systems was used as reference, and sustainability indicators were incorporated based on the Framework for the Evaluation of Management Systems Incorporating Sustainability Indicators (MESMIS, by its Spanish acronym)[11][16]. This framework allowed for an approximation and synthesis through the hierarchization of indicators that evaluate short- and long-term system sustainability.

At the same time, workshops were held with the board of directors and associates, along with structured, semi-structured, and in-depth on-farm interviews[17], mapping of problems[18], and preparation of diagnostic assessments. This stage concluded with the construction, together with the producing families, of a problem tree[18] for each farm, which enabled the creation of redesign plans aimed at introducing and promoting strategic changes[19].

Monthly visits were conducted to participating families, during which a participatory dialogue was established to understand their needs, concerns, and objectives. Data were collected for the construction of indicators that allowed the characterization and diagnosis of each production system through a process of continuous exchange.

The articulation of methodologies was carried out by adapting approaches of other agricultural sectors to the realities of these production systems. The complexity of the systems, the degree of actors' involvement, the diversity of the technical team, and the dynamics of the sector required combining multiple methodological strategies and tools to effectively conduct the characterization and diagnostic stage.

2.2 Description of the Selected Farms

Four family pig production farms were selected, based on the criteria defined between the technical team and the Cooperative members. The selection criteria were designed to ensure representativeness of the pig production systems in the south of the country, which commercialize part of their production through CALUPROCERD, as well as the availability of the family producer to actively engage in the project and participate in the collective activities. **Table 1** presents the main characteristics of the selected production systems.

Table 1. Description of the selected production systems

		Farm 1	Farm 2	Farm 3	Farm 4
Geographical location		Villa del Rosario, Lavalleja	Los Arenales, Canelones	Cabaña Anaya, Montevideo	San Bautista, Canelones
Importance of the pig item in the production system		Primary	Tertiary	Primary	Primary
Other items		Equines	Poultry (primary), cattle, and sheep	Cattle	Poultry, sheep
Productive orientation		Breeding	Breeding	Full cycle	Full cycle
Genetics		Undefined crosses	Undefined crosses	Undefined crosses	Large White, Landrace, Terminal Hybrid
Feed*		Rations and by-products	Rations and by-products	By-products	Rations and by-products
Facilities**	Nursing	Confined	Semi-confined	In the field	Confined
	Rearing - finishing	-	-	Confined	Confined
No. of breeding females		12	12	60	30

Note: *Main by-products: bakery sweeping and industrial dairy waste. **In all systems, gestation and service take place in the field.

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2.3 Economic Indicators

For the economic dimension, information on cash and non-cash income and expenditures was collected through interviews with producers, covering the last two production years, each delimited between July 1 and June 30, 2022-2023 (production year 2) and 2023-2024 (production year 3). For year 1, 2021-2022, the economic records were collected mainly from the memory of the families, since the only records available were the DICOSE declaration and possible farrowing dates, and the number of weaning piglets. The indicators used are grouped into global economic indicators and activity-specific indicators.

2.3.1 Global Economic Production Indicators

For the in-depth assessment of family production systems presented in this article, a set of global indicators[20][21], detailed in **Table 2**, was developed.

2.3.2 Activity-Specific Economic Indicators

The economic indicators of activity (**Table 3**) were constructed based on margin analysis[20][21].

Table 2. List of global economic indicators

Indicator	Description
Total Income (TI)	Represents the sum of net household income from off-farm income.
Total Income per Person (TIP)	Obtained by dividing TI by the number of people who contribute to the family nucleus.
Ratio TIP/rural administrator wages*	Estimates the opportunity cost by comparing the total income per person to the wages of a rural administrator.
Ratio TIP/TBB Income (PL)**	It compares the ratio of income per person to the income required to cover a total basic basket (TBB) and determines the level of the poverty line.
Gross Product (GP)	Monetary value of all the production generated, whether sold or not.
Total Costs (TC)	It considers the total expenditure for goods and services that the company consumes in a single year to produce other goods, including lease and interest costs. It reflects both direct costs involved in a particular area and overall enterprise-level costs, regardless of the area exploited.
Equity Income (EI)	These are the producer's profits through total gross product (TGP) minus total costs (TC).
Family Labor (FL)	Family wages (usually non-cash items).
Net Household Income (NHI)	Measures the return to producers for their labor and organizational role in the production system, as well as for owning the resources involved. It is the sum of EI and FL.
Ratio NHI/TBB Income (PL)	Relates the NHI to the cost of a total basic basket (TBB).
Ratio NHI to Average Rural Household Income **	Compared NHI to the total average income of a rural household: wages, retirements, pensions, annuities, and transfers. It is used to measure purchasing power.

Source: *(Unpublished material from the Wage Council group no. 22: livestock, agriculture and related activities; not referenced). **(Unpublished material from the National Institute of Statistics; not referenced).

Table 3. List of economic indicators of activity

Indicator	Description
Pig gross product (PGP)	Pig sales + self-consumption - purchases +/- inventory difference
Direct Pig Costs (DPC)	Costs incurred by the company due to the exploitation of the pig sector.
Pig gross margin (PGM)	Represents the economic return from pig production after deducting the inputs required to produce it. This allows comparison across different enterprise types that compete for the same resources or among similar enterprises. It implicitly reflects economic efficiency from a technological perspective. Calculated as PGP minus DPC.
Feed Margin (FM)	PGP minus the feed costs consumed by pigs.

3. Results

3.1 General Diagnostic Results: Main Problems Identified

The system diagnostics concluded with individual reports for each producer, analyzing the economic indicators and developing problem trees. From the workshops with the cooperative members, shared problems were observed around productive inefficiency, such as high piglet mortality (>28%), extended post-weaning period (piglets ages >80 days), and long periods of non-productive sows (>16 days). For these problems, alternatives were designed to overcome the main limitations identified by the families.

Figure 1 presents some of the proposals focused on improving productive indicators. These proposals were developed collaboratively between the technical team and the families, considering, among other aspects, that they were feasible to implement in the short and medium term. Likewise, the figure also represents their degree of implementation in the different systems at the time of writing.

Redisign proposals	Farm 1	Farm 2	Farm 3	Farm 4
Productive record keeping	●	●	◑	◑
Implementation of a basic health plan	●	●	●	●
Use of balanced diets in the breeding stock	●	●	◑	●
Improvements in infrastructure to meet piglet housing requirements	●	●	◑	●
Free access to water for animals	sp	●	●	sp
Infrastructure improvements for adult pigs management	○	○	○	○
Early castration of piglets destined for finishing	sp	◑	◑	◑
Quarantine area	○	○	◑	○
Shade for animals	sp	○	sp	○

References	●	◑	○	sp
	activity implemented between 80–100%	in the process of being implemented	activity not yet started	implemented by the producer before the project started.

Figure 1. Proposals incorporated in the redesign of family production systems

The actions focused on improving productive indicators, which have a direct impact on economic indicators.

3.2 Evolution of the Economic Productive Outcomes on the Analyzed Farms

The results of the three monitoring periods for each production system, based on selected economic indicators, are presented in **Table 4**, **Table 5**, **Table 6**, and **Table 7**.

In the production system identified as Farm 1 (**Table 4**), the economic indicators are presented as favorable, although they should be interpreted with caution due to the data quality limitations. For recent years, net household income (NHI), which includes income from equity and unpaid family labor, was negative. However, total income (TI), which includes NHI and off-farm income, was positive in all three periods. These two indicators, TI and NHI, contribute positively to the economic sustainability of this production system, as they reflect reliance on off-farm income (in the case of TI) and unpaid family labor (in the case of NHI), particularly when total costs exceed the total gross product.

Table 4. Global and activity-specific indicators for Farm 1 for the three evaluated years

Economic indicators Farm 1	Year 1	Year 2	Year 3	% change from year 2 to year 3
GLOBAL INDICATORS (PESOS)				
Total Income (TI)	763,544	148,870	337,533	127%
Total Income Per Person (TIP)	381,772	74,435	168,767	127%
Net Household Income (NHI)	277,141	-389,130	-232,807	40%
Total Gross Product (TGP)	1,051,083	1,617,702	2,142,721	32%
ACTIVITY INDICATORS (PESOS)				
Pig Gross Margin (PGM)	-27,124	-508,692	-176,935	65%
Feed Margin (FM)	427,529	63,064	257,879	309%
Pig Gross Product (PGP)	787,529	1,567,062	1,816,801	16%
Direct Pig Costs (DPC)	814,653	2,075,754	1,993,736	-4%

Note: GM and FM per kg could not be calculated due to lack of records.

At the level of indicators by activity, pig gross product (PGP) increased in years 2 and 3 due to the increase in piglet sales, as a result of the increase in the herd, which went from 12 to 64 breeding females between years 1 and 2, followed by a stabilization at 54 females in year 3. Although farm income increased from piglet sales, variable costs also increased due to the greater feed volume, which responds to the stock growth and the gradual change from feeding with by-products to a system based on balanced rations. This led to high feeding costs with unfavorable margins (PGM) for the three years. In the last financial year, the gross margin improved due to an increase in gross product and more efficient feed use, which implied an increase in its margin (FM). The pig share of total gross product (PGP as % of TGP) increased from 75% in year 1 to 85% in year 3.

Table 5. Global and activity-specific indicators for Farm 2 for the three evaluated years

Economic indicators Farm 2	Year 1	Year 2	Year 3	% change from year 2 to year 3
GLOBAL INDICATORS (PESOS)				
Total Income (TI)	1,196,133	1,134,454	1,419,659	25%
Total Income Per Person (TIP)	797,422	756,303	946,439	25%
Net Household Income (NHI)	1,056,063	984,454	1,256,639	28%
Total Gross Product (TGP)	2,333,709	1,812,195	2,322,016	28%
ACTIVITY INDICATORS (PESOS)				
Pig Gross Margin (PGM)	-294,121	-22,869	91,486	500%
Feed Margin (FM)	-127,445	121,475	319,490	163%
Pig Gross Product (PGP)	507,950	290,160	555,444	91%
Direct Pig Costs (DPC)	802,071	313,029	463,958	48%

The production system identified as Farm 2 (**Table 5**) is the only one in which the pig gross product does not exceed 25% of the total gross product. It is a farm that has four items, and poultry production has the largest participation for the three years, between 50 and 63% of the total gross product. The diversification of the production system into four areas, but with greater emphasis on poultry, determines better overall results.

Throughout the entire period, this family farming system showed a consistent strength: a positive total income, regardless of off-farm income. Considering the average NHI of the three years, which includes the remuneration of family labor (non-cash income) and the income from equity (the value of goods produced), the income level is twice the annual wages of a rural farm administrator (2023-2024).

In terms of activity indicators, the first two years showed an adverse gross margin, associated with high direct costs in relation to the gross product generated, particularly feed costs in the first production year (2021-2022). Between years 1 and 2, the number of sows decreased and this category was replaced with gilts. The absence of records in piglet sales could also explain the negative GM for pig activity during the first productive year 2021-2022.

The gross margin in the second production year improved compared to the first due to a decrease in direct costs, largely a result of reduced feed use following the complete replacement of sows with lighter gilts and the reduction in the number of breeding females (from 12 to 8). Although the pig gross product also decreased, costs declined at a proportionally higher rate. In the last production year, a rise in gross product was observed due to increased piglet production. This growth is likely the result of improvements in the health and nutritional plan of the breeding stock, reflected in an increase in the number of weaned piglets/sow/year, both measures implemented as part of the ongoing redesign proposal. The use of feed rations was reflected in higher direct pig costs.

Table 6. Global and activity-specific indicators for Farm 3 for the three evaluated years

Economic indicators Farm 3	Year 1	Year 2	Year 3	% change from year 2 to year 3
GLOBAL INDICATORS (PESOS)				
Total Income (TI)	815,815	927,673	1,441,058	55%
Total Income Per Person (TIP)	407,906	463,837	720,529	55%
Net Household Income (NHI)	325,159	447,673	934,658	109%
Total Gross Product (TGP)	2,208,994	2,235,092	3,027,425	35%
ACTIVITY INDICATORS (PESOS)				
Pig Gross Margin (PGM)	647,937	638,878	1,096,172	90%
Feed Margin (FM)	1,235,051	1,299,471	1,849,843	42%
Pig Gross Product (PGP)	2,098,830	2,163,600	2,937,673	36%
Direct Pig Costs (DPC)	1,450,893	1,524,722	1,841,500	16%

Farm 3 (**Table 6**) shows the largest contribution of the pig production to the total production (over 95%). Total income for the first two production years, which includes off-farm salaries, was double the NHI, except for the last year, due to PGP improvements. This underscores the relevance of off-farm income for the economic sustainability of family farms, since it complements the income generated within the farm system. In the first two years, the NHI represented 59 and 82% of the wages of a rural administrator, respectively; in the last year, the NHI nearly doubled those wages.

Analyzing the economic indicators of activity for this system, all three periods showed an increase in TGP and direct costs associated with pig activity, which could be explained by the application of the health plan (**Figure 1**), which decreased piglet mortality and sow non-productive days. Likewise, the incorporation of balanced diets contributed to the improvement of the indicators, but increased the direct costs. This farm obtained a positive

gross margin for pigs throughout the entire period analyzed, with a 90% increase between the second and third years, due to a proportionally greater rise in gross product compared to direct pig costs.

Table 7. Global and activity-specific indicators of Farm 4 for the three evaluated years

Economic indicators Farm 4	Year 1	Year 2	Year 3	% change from year 2 to year 3
GLOBAL INDICATORS (PESOS)				
Total Income (TI)	-117,298	1,025,242	2,443,831	138%
Total Income Per Person (TIP)	NA*	NA*	NA*	
Net Household Income (NHI)	-396,058	169,642	1,518,631	795%
Total Gross Product (TGP)	1,556,035	2,566,039	3,477,795	36%
ACTIVITY INDICATORS (PESOS)				
Pig Gross Margin (PGM)	-586,388	-151,255	1,141,141	854%
Feed Margin (FM)	-93,822	444,783	1,785,009	301%
Pig Gross Product (PGP)	1,338,480	2,281,608	3,111,741	36%
Direct Pig Costs (DPC)	1,924,868	2,432,863	1,970,600	-19%

Note: *NA = Not Applicable.

Farm 4 (**Table 7**) is the second production system whose main activity is pig farming, accounting for more than 84% of the total gross product. Likely, omissions or inconsistencies in animal inventory and sales data during the first period contributed to the negative global indicators for total income and net household income. This situation could explain the marked variation in favor of the NHI observed in year 3 compared to year 2.

The increase in TGP and PGP resulted from an increase in pig production, explained by higher sales of pigs, gilts and piglets, greater self-consumption, and higher final inventories for all categories except breeding sows. This increased productivity was attributed to the implementation of the proposed health plan, the use of balanced diets for the breeding stock, and improvements in breeding infrastructure (**Figure 1**).

Regarding the activity indicators, an increase in the gross margin of pigs was observed in the third year. This improvement in PGM is the result of an increase in volume of pigs produced and a 22% increase in the price per kilogram. In addition, the implementation of a health plan contributed to a greater number of piglets born, positively affecting productivity. Alongside production growth, the feed margin was higher while the direct feed costs decreased by 19%. This reduction occurred because, despite similar amount of feed purchased in years 2 and 3, the amount of kg produced by piglet/sow was higher, leading to greater efficiency in the last year.

In this particular farm, the off-farm income (from wages, subsidies and sales of other products) from the first two years contributed significantly to the economic sustainability of the production system.

4. Discussion

For the case studies selected as representative of the production systems linked to CALUPROCERD, pig production is the main generator of the gross product in three of the four systems studied. It is likely that the association with the Cooperative, characterized by a strong commercial commitment, provides families with security

and confidence in this activity, determining pig production as the main activity of these production systems. This association strengthens the development of the sector, by guaranteeing each producer a fixed quota of live weight in kilograms and a pre-established price, linked to the quality of the carcass[1].

On the other hand, the Cooperative's business model has required producers to implement technological transformations on their farms to ensure both the quantity and quality of the commercialized product, which is one of the main concerns of CALUPROCERD's board of directors and one of the challenges identified in this study.

Through the methodological approach of participatory action research, work was carried out with the families to identify limitations, select the most suitable technological proposals for their specific production systems, and subsequently monitor their implementation. For example, improvements in farrowing infrastructure were introduced, with different solutions in each farm to ensure optimal housing conditions for piglets, as well as dietary adjustments during the rearing and finishing stages.

As already mentioned, the case studies did not have economic records prior to the start of the project, which was noted as a constraint in the analysis of the first production year. However, throughout the participatory process with the families, it was possible to define a mechanism for each farm to record productive events as well as economic inputs and outputs, which allowed the information for the second and third years to become more consistent and reliable.

The progressive incorporation of the record keeping was a fundamental tool for the analysis of the production systems, and responded to the strengthening of trust bonds relationships built throughout the project. The use of data and its constant monitoring allowed comparative evaluations within each farm, and provided valuable information for decision-making based on productive and economic indicators, which contributed to improving the efficiency and product quality[22].

Analyzing the economic results, positive total income was identified for the four family production systems evaluated. When considering the total income per person (TIP) as the average of the three years analyzed, two farms reported TIP values above the annual wages of a rural administrator, one was close to equaling it, while the one with the lowest result stood at 38% of the wages. This scenario reflects the importance of the off-farm income of these family production systems, which had a relevant participation when included in the TI for three of the farms, reaching values of 44, 61 and 128% of the total income of the families, respectively. Similarly, another study[11] found that off-farm income represented more than 72% of total household income in five of six family pig production systems analyzed. Off-farm income and pluriactivity in family production systems were reported by other authors[23][24], who found that pluriactivity is the most common strategy among "non-commercial" producers.

In all four farms, the productive units rely mostly on family labor, with a limited use of waged labor, generally on the harvest season. However, they share the general trend of family production, where members of the producing family seek or maintain off-farm employment[23]. In these cases, external income is used as a strategy to sustain production[23]. One of the strengths identified among the farms analyzed in this study is that, for three of them, the TIP was between five and eight times higher than the income level required to meet basic needs in rural areas, while in the remaining one it was more than twice that level. However, other authors[25] highlighted, in their research with sixteen horticultural and mixed horticultural-livestock producers in Canelones, that most family production systems presented lower productive, economic, social, and environmental results compared to their achievable potential. According to these authors, this situation was driven by serious deficiencies in the management of natural resources and in the organization of the production system. The economic results indicated that most of the families in the farms evaluated had incomes below the regional average. We understand

that these global economic indicators are representative of a reality that affects the sustainability of family farms, both in terms of quality of life and generational renewal.

In this regard, a study conducted in the state of Paraná[26] argues that the concept of "simple reproduction", whereby farmers obtain a minimum income necessary to reproduce their family and production system, must be dynamic over time. This reproduction threshold was estimated at three minimum wages for an average rural family of 4.14 people in the municipality of Guaraqueçaba, southern Brazil. Therefore, situations can coexist where the limit of simple reproduction is exceeded but remain unable to subsist over time due to market adversities, or conversely, cases of families that remain below the minimum reproduction level yet manage to survive under conditions of deprivation or declining living standards.

Considering the net household income (NHI) obtained in this study above the rural poverty line in Uruguay that covers a total basic basket (TBB), three of the systems analyzed showed NHI values in a range of 1.40 to 4.29 exceeding the TBB; while Farm 1, as already indicated, fell below it. This validates, on the one hand, the maintenance of these family farms over time, sustained by both pig production and off-farm income. This also explains why farms 1 and 4 obtained the lowest ratios of NHI over the average rural household income index, which measures purchasing power, coinciding in that both farms have the highest off-farm income (128 and 61% of total income, respectively). From this, a strong hypothesis arises suggesting that this situation may relate to one of the key issues affecting generational renewal.

In a similar study applying a participatory co-innovation methodology to horticultural and mixed farming systems, the authors argued that the low economic efficiency, diagnosed in most of the farms, is one of the major problems in the sustainability of these systems, due to the difficulty in competing with other sectors for labor (both family and waged) and the difficulty not only of increasing but also of maintaining the productive capital[25]. In the present study, it was observed that Farm 2, with the lowest percentage of off-farm income over total income, but with the greatest diversification of items, reflecting pluriactivity, obtained the highest ratios between total income per person and the basic basket, and net household income relative to the average household income index.

When analyzing the relationship between feed costs and direct pig costs (DPC), values ranged between 44 to 79% across all systems and years. A national study[11] obtained feed costs between 65 and 85% of the direct costs of six family pig farms studied in the department of Canelones, corresponding to mostly outdoor breeding systems. These results confirm, once again, the relevance of the cost of feed within the direct costs associated with pig production, regardless of the production orientation. The use of the by-product as feed ingredients places some systems in the lower values of the range (Farms 2 and 3) compared to those relying mainly on balanced rations (Farms 1 and 4).

Finally, the interdisciplinary work has been a fundamental challenge for the team and allowed, through research and extension, the active integration of the family in the process. This approach facilitated the exchange of data, experiences, and common problems, all guided by the main objective of ensuring the continuity of family pig production. In this regard, the working methodology has not only had a direct impact on the families involved but has also strengthened the collaboration with the Cooperative, whose role is key to the stability and resilience of these production systems. Thus, the relevance of collaboration between technicians, producer families, and CALUPROCERD is highlighted as a basis for promoting the continuity and sustainable development of family pig production in southern Uruguay.

5. Conclusions

Family pig production in Uruguay faces structural problems shared by other sectors of family farming, such as market integration for inputs and products, and access to technology. Some of these factors have a direct impact on the economic performance and long-term sustainability of the systems, while conditioning the process of generational renewal. Many of these structural problems –which go beyond the internal dynamics of production systems– require collective action from rural organizations, as well as the existence of sector-oriented public policies. In this context, the Law on Public Procurement for Family Agricultural Production represents a significant advance in terms of guaranteeing a differentiated market for these social subjects. Although marketing through the Cooperative serves as an incentive for families to continue pig production, by obtaining better prices than they would individually, the sector still faces strong competition at the national level due to the large volumes of pork imported from Brazil, which makes competitiveness difficult.

The project, based on the in-depth diagnosis of the productive-technological dynamics of the farms, enabled the identification of a series of common issues that affect pig-producing families, such as low productivity (associated with inadequate infrastructure and management problems) and high costs. The economic results obtained for these family pig production systems show low efficiency to generate capital income, due to the total costs, particularly those associated with quality feed for the pig stock.

In general, the total income and net household income achieved have been sufficient for the maintenance of families on the farm and the continuity of pig production. There were even significant increases in the gross margins of pig production and feed, explained by the intervention of the technical team working collaboratively with producers. Nevertheless, these systems remain vulnerable, considering that only one farm in this study achieved a net household income above the average household income for rural areas in the country. This situation leads families to develop pluriactivity strategies and to complement their income through off-farm wage labor.

The technical approach in family production systems requires a comprehensive and interdisciplinary approach. Participatory processes and knowledge co-construction seek to develop proposals adapted to the realities of each family farm system. The experience of working with producer families through this methodology showed that the progressive incorporation of technological changes based on experimentation and practical learning is an effective way to improve productive and economic indicators, supported by the systematic use of records. This participatory and collaborative approach has created an enabling environment for improvement and resource optimization, thereby contributing to the long-term sustainability of productive activities.

In family production systems, where the family is a fundamental pillar, CALUPROCERD faces the challenge of expanding its role beyond commercial activities to include actions that allow access to technical assistance and rural extension services, as well as improving the living conditions of families. Such improvements are essential to strengthen the stability and continuity of productive activities, and thus consolidate family pig production systems.

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Transparency of data

Part of the data set that supports the results of this study was published in the article itself.

Author contribution statement

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Conceptualization	■	■	■	■		■
Data curation	■	■		■		■
Formal analysis	■		■		■	■
Funding acquisition						■
Investigation					■	
Methodology	■	■	■		■	■
Project administration	■					
Supervision						■
Visualization	■					
Writing – original draft	■					■
Writing – review and editing	■	■	■			■

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